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SYNCHRONISM AND SYNCHRONIC RHYTHM IN THE BEHAVIOR OF CERTAIN CREATURES

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It is a matter of common experience to observe instances of synchronous behavior and expression among creatures. In such instances an entire group of creatures may react simultaneously to the same external stimulus. A flock of birds will arise from the ground and dash away at the first signal of danger, or a school of fish will swerve as a unit from a stick pushed toward them. In the same way certain frogs in a pool may be started into a brief, explosive chorus of simultaneous croaking by the notes of a single individual. After a brief period during which all have expressed themselves, silence ensues until the next singing-reflex is unlocked by the croaking of another individual. In New England I have heard the wood frog, or so-called clucking frog (*Rana sylvatica*) give rise to just such outbursts of simultaneous clucking, started either by the frogs themselves or by my giving an imitation of their notes during an interval of silence. This habit of singing in concert is not unusual among certain species of frogs, and is mentioned by D. D. Cunningham (1903) in his excellent book, "Some Indian Friends and Acquaintances." He says:

> Such utterances recur several times in succession; a short pause follows and then the conversation begins again. The curious thing is that all the performers seated in one patch of swamp should have such a tendency to synchronous action that periods of total silence alternate with those of general uproar. The phenomenon is parallel to that of the synchronous luminosity that sometimes occurs so markedly in groups of fireflies.

In these instances synchronism is maintained at intervals, but there is no regular rhythmic expression within the group itself. Each frog croaks in its own way, until a perfect babel of noise is produced.

Similar synchronous outbursts of sound also occur among the musical insects. The tendency to respond to the notes of their kind is very strong, and a single singer may be followed by thousands. Although the seventeen-year cicada rarely sings at night, Hopkins[1] noted a most remarkable nocturnal concert which began with a single singer. He says:

> I was fortunate enough to hear the starting of one of these concerts on a clear, moonlight night in June. One male in an apple tree near the house suddenly called out as if disturbed or frightened. His neighbors in the same tree were thus apparently awakened. One started the familiar song note, which was at once taken up by numbers of other males, and, like the waves from a pebble dropped into still water, the music rapidly spread until it reached the edge of the thick woods, where it was taken up by thousands of singers, and the concert was in as full blast as if it had been the previous day. This continued a few minutes, until all had apparently taken part and the song had reached its highest pitch, when it began to gradually subside, and in a short time silence again prevailed.

In his book, "Bolivia" (1914), Paul Walle (p. 268) speaks of the sudden outbursts of noise in the tropical wilderness as follows:

> As the darkness grows deeper, the silence of the forest is broken by the sound of flight, by sudden rustlings, or by a strident shriek. Immediately the creatures of the forest raise their various cries, the uproar lasts for a moment, and all relapses into a silence in which one still hears, more or less sensibly, the murmur of a million insects.

In such instances where a group of creatures respond simultaneously to the same initial stimulus, we have the simplest case of synchronic behavior. I once witnessed an instance of a similar synchronic behavior in the movements of a colony of plant lice which thickly covered the tip of a twig. While I was watching them, a tiny, parasitic wasp suddenly approached and hovered over the colony preparatory to attacking them. The plant lice became aware of its presence and in an instant the entire colony raised the hind portion of their bodies simultaneously into the air at an angle of about 45° and began waving their hind legs about. This behavior was probably more or less a protective response to the primary stimulus afforded by the presence of the wasp. It is also possible that the reaction, once started in a few individuals, would tend to be transmitted to the entire colony by the mere contact of their bodies.

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[1] "The Periodical Cicada," by C. L. Marlatt, Bull. No. 14, Div. of Entomology, U. S. Dept. of Agr., 1898, p. 58.

The same sort of synchronous movement may sometimes be noted in the reactions of the leaves and leaflets of the sensitive plant (*Mimosa pudica*). A sudden shock may cause every leaf of the plant to react synchronously. Sometimes, when the stimulus is applied only to one or two pairs of the basal leaflets, the closing of these and their contact with those beneath them produce a progressive closing movement in all the pairs of leaflets until the terminal ones are reached. In this instance we have a progressive transmission of stimuli quite similar to the transmission of certain automatic reactions which sometimes take place in groups of insects, birds, or animals.

In other instances the reaction to a certain stimulus may involve several similar, instinctive movements producing the simplest form of synchronic rhythm. One interesting instance of this sort of synchronous action has been adduced by H. H. Newman, in *Science,* N. S., for January 12, 1917. Newman found that an enormous colony of "harvestmen," of the genus *Liobunum,* resting beneath an overhanging rock, when disturbed began a rhythmic body movement, raising their bodies up and down at a rate of about three times a second, for a brief period. If the stimulus was set up in a few individuals of the colony, the synchronous body movements spread rapidly over the entire colony. After a time it was found that the reactions became weaker and finally ceased. In this instance it appears that there was a secondary transmission of the stimuli from individual to individual by means of their closely interlocked legs. The writer has noted a similar behavior among the individuals of certain caterpillars which were arranged close together on a twig. These caterpillars, when resting, had the habit of keeping the anterior portion of their bodies raised in the air. If the colony was disturbed, each individual began a synchronous swinging of the free portion of the body from side to side, violently, for a brief period. The primary stimulus could affect all the caterpillars of a group, or a secondary transmission could take place down the twig. Although the swinging was not always in the same direction, a remarkable degree of synchronic movement was brought about.

In those instances where the rhythmic expression of each individual, when set up, continues for long periods of time, as in the case of certain crickets, we have the development of a more complex synchronic rhythm having its origin in the instinctive habit of response, and probably also built up and maintained by the unconscious influences of the regular sounds of the crickets upon one another.

I do not feel the slightest hesitancy in affirming that certain crickets which have the intermittent habit of chirping may build up and maintain a synchronic rhythm under favorable conditions. I refer to the well-known snowy tree cricket (*Œcanthus niveus*), whose synchronous music has been noted and described by many well-known observers and naturalists in this country. I have many times heard the remarkable synchronous chirping of these crickets in New England, and under exceptionally favorable conditions the synchronism has been so marked that waves of solemn, rhythmical music have been produced for long periods of time. This rhythmic music was spoken of as a ''slumbrous breathing'' by Thoreau. Hawthorne called it an ''audible stillness'' which, ''if moonlight could be heard, it would sound like that.'' Burroughs called it a ''rhythmic beat.'' McNeill has said of the music of this cricket:

> It is heard only at night and occasionally on cloudy days, but in the latter case it is only an isolated song, and never the full chorus of the night song produced by many wings whose vibrations, in exact unison, produce that characteristic "rhythmic beat," as Burroughs has happily phrased it.

Dolbear, in the AMERICAN NATURALIST for November, 1897, refers to this cricket when he says:

> At night, when great numbers are chirping, the regularity is astonishing, for one may hear all the crickets in a field chirping synchronously, keeping time as if led by the wand of a conductor.

Although the facts may have been slightly overdrawn when Dolbear stated that *all* the crickets in a field were chirping in unison, Shull was not justified in concluding that the synchronism observed by Dolbear was merely an illusion. If such were the case, it is surprising that so many other excellent observers have also been misled by the same illusion in reporting the music of the snowy tree cricket. For many years I have made a very close study of the stridulations of insects, yet I have noted this synchronous chirping in but one other species of those crickets which possess the intermittent habit of trilling. One may frequently hear great numbers of the common field cricket (*Gryllus pennsylvanicus*) chirping in the fields, but these crickets never show the least tendency to chirp in unison as do the snowy tree crickets. The jumping tree cricket (*Orocharis saltator*) is also an intermittent triller and may sometimes be heard chirping in great numbers in certain copses, yet the "illusion" of synchronous trilling one somehow never experiences. Likewise, there appears to be no tendency whatever for the ground crickets, *Miogryllus saussurei, Nemobius fasciatus*, or *Nemobius ambitiosus*, to chirp in unison. Many other locusts and katydids, such as *Conocephalus ensiger, Conocephalus exiliscanornus*, and the common katydid (*Cyrtophyllus perspicillatus*) produce regular, intermittent notes and stridulate in well-defined colonies, yet so far as I have observed the individuals of a species never show the least tendency to stridulate in unison.

In the south, however, I have heard the tiny tree crickets (*Cyrtoxipha columbiana*) chirping in unison with remarkable precision, producing waves of shrill, rhythmic sound, as in the case of the snowy tree cricket. In this instance great numbers of these crickets were located in the branches of a large evergreen holly tree. The shrill notes of this little cricket are delivered with great regularity, as are the low, solemn chirping notes of the snowy tree cricket. This regularity in the delivery of the chirping of these two crickets is especially striking when compared with the musical efforts of other chirping crickets, such as *Œcanthus angustipennis, Orocharis saltator*, or *Gryllus pennsylvanicus*. This sustained regularity in the rate of chirping of the snowy tree cricket has been noted by various observers. On the supposition that the rate of chirping of these crickets is entirely a function of temperature, it has even been considered that the crickets may serve as an accurate thermometer. As temperature indicators, however, the crickets can not always be relied upon under all conditions, since wind, humidity, and electrical conditions of the atmosphere preceding thunderstorms, also appear to influence the activities of these insects.

It is now a question as to whether these crickets perceive the rhythm which is so pronounced in the regular sequence of their chirpings. I believe they must, for it is quite evident that they hear and respond to the peculiar rhythmical chirpings of their kind, which have become the common language of the species. If they are able to recognize the notes of their kind, it is reasonable to believe that the rhythmic character, as well as pitch, manner of delivery, and even more subtle tonal differences enter into the recognition.

The rhythmic chirping in unison which oftentimes becomes such a pronounced feature in the music of these crickets takes place only in the evening and appears to depend upon the nice adjustment of certain nocturnal atmospheric relations—moonlight, temperature, humidity, and stillness of the air. Early in the evening, perhaps, a single cricket begins its stridulations which stimulate others to respond, and by degrees the great chirping chorus is augmented. There may be no noticeable synchronism in the chirping at first, but if conditions are favorable, the crickets gradually build up a synchronic rhythm until waves of solemn music are produced by a certain colony.

There seems to be a marked tendency for the individuals of each colony to adopt the rhythmic beat of their particular colony, so that not infrequently a neighboring colony may establish an antiphonal rhythm, with the result that waves of quavering sound swing backward and forward between two neighboring colonies.

How is this synchronal chirping built up and maintained? It is probable that the instinctive habit of response tends to bring the chirping of many individuals into a regular synchronism, but I feel, also, that the crickets are somehow unconsciously influenced by one another in their chirpings so that they tend gradually to build up a common synchronic rhythm as the night advances. Once a synchronic rhythm is established, I am inclined to feel that it would be natural for those individuals which began chirping, at first asynchronously, to chirp, sooner or later, in unison with their fellows.

From the tone of certain discussions which have taken place in *Science* for the past several months, it is clearly indicated that the synchronous flashing of fireflies as a reality is somewhat doubted. There is no reason to consider such synchronism "contrary to all natural laws," as Laurent as recently stated in *Science* for January 12, 1917. In the tropics it appears that great numbers of fireflies frequently establish themselves in the crowns of certain trees, and I am not at all ready to deny that under certain conditions such colonies may not flash synchronously, as reported by Cunningham (*loc. cit.*), Shelford, and others. It is unfortunate that in most instances these reports are accompanied by very meager details as to the general behavior of the fireflies in these arboreal colonies. Cuthbert Collingwood, however, in his book, "Rambles of a Naturalist," (1868), pp. 254–255, has given a very careful account of his observations of the synchronous flashing of fireflies, as follows: "At Singapore, and also at Labuan, the little luminous beetle commonly known as the firefly (*Lampyris Sp. Ign.*) is common. When flying singly it shines with an intermittent light which alternates with darkness; but on fine evenings and in favorable (*i. e.*, damp and swampy) locations, they present a very remarkable appearance. Clustered in the foliage of the trees, instead of keeping up an irregular twinkle, every individual shines simultaneously at regular intervals, as though by common impulse; so that their light pulsates, as it were, and the tree is for one moment illuminated by a hundred brilliant points and the next is in almost total darkness. The intervals have about the duration of a second, and during the intermission only one or two remain illuminated. To all appearances they are not on the wing at the time but settled upon the tree; for I was able to recognize certain points of light which I especially noticed, and which remained in the same situation with each successive flash. When I disturbed them under such circumstances they flew about at random, each giving out a more rapidly intermittent light. At Labuan, however, I have frequently seen them shine with a steady light as they flew along looking like little, flying stars of the second, or even first, magnitude.'' If there are periods of repose or inactivity during which the insects cease their flashing, it is easy to see how a part of the colony or even all the insects could react simultaneously to the same visual stimulus, such as the sudden flashing of a single individual. If it is the habit of the insects, before again becoming quiescent, to flash several times in succession, following an appropriate stimulus, it is very easy to see how distinct synchronous flashes of light would now and then illuminate a portion of the tree, or even the entire tree. Such synchronic rhythm in the flashing of fireflies would be similar in every way to those instinctive, automatic body movements observed by Newman in the case of the ''harvesters,'' *Liobunum*—the swinging of the pendulum, so to speak, two, three, or more times, as the case may be, following the initial stimulus. As Newman well suggests, it is possible that a transmission of stimuli could even build up and maintain for some time a synchronous flashing in colonies of fireflies in a tree or field. This flashing in unison would parallel the synchronous trilling of the snowy tree crickets, and would not necessarily violate known natural laws governing the instinctive synchronic activities of various creatures.

By selecting two individuals which were evidently chirping in unison, Shull[2] attempted to study the reality of synchronous chirping in a colony of snowy tree crickets by statistical methods. No greater statistical fallacy could be adduced, however, than to attempt to determine the reality of synchronism in a colony of chirping tree-crickets from statistical results obtained for only two crickets of the colony. That synchronous chirping may be a reality, it is not necessary that 100 per cent. of the individuals of a colony chirp exactly in unison. A few crickets chirping asynchronously would not necessarily prove that a synchronism did not exist. As a matter of fact, some individuals always chirp asynchronously, even when the synchronic rhythm is most pronounced. Taking any two crickets from such a colony, the results would depend entirely upon which two crickets were chosen, and either perfect synchronism or absolutte lack of synchronism, would be established.

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[2] Shull, A. F., ''The Stridulation of the Snowy Tree-cricket (*Œcanthus niveus*),'' *Canadian Entomologist*, Vol. 39, 1907.

It is obviously impossible to subject all the individuals of a colony of chirping tree-crickets or a group of flashing fireflies to statistical analysis. Because this is impossible, however, one is not justified in concluding that judgment based upon careful observation is of no value in determining the reality of synchronism. If one hundred men were marching down a street and 75 were in step while 25 were not, judgment alone would establish the fact that a synchronic rhythm existed. This would be quite as true for the chirping of tree-crickets or the flashing of fireflies. As a matter of fact some of the most marvellous discriminations depend upon niceties of judgment alone, and no amount of statistical data would simplify the matter.

I can not yet agree with those who are inclined to believe that the snowy tree-crickets never chirp synchronously, and that it is impossible for fireflies to flash synchronously, especially certain tropical species of fireflies. I will agree, however, that in practically all instances of synchronic rhythm there seems to be no evidence of conscious, intentional imitation, but merely instinctive, reflex, or automatic reactions to certain stimuli, similar in many respects to the unconscious reactions of the leaves and leaflets of the sensitive plant.